Geo-Fence Integrated Iot Framework For Children Health And Safety Assurance

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Abstract- *The current invention is about a Geo-Fence integrated Internet of Things (IoT) framework focused on health and safety insurance for children. This system combines real-time monitoring of health, detection of environmental hazards, and location tracking into a single embedded platform. The device uses an ESP32 microcontroller along with a pulse sensor, temperature sensor, smoke sensor, ultrasonic sensor, GSM-GPS module, and a camera module to continuously monitor a child's health and surroundings. The framework allows for smart monitoring by gathering, processing, and sending data through embedded C programming.*

The system tracks essential health metrics like heart rate and body temperature while also detecting environmental risks such as smoke and unsafe proximity to hazards. The GSM-GPS module provides real-time location tracking and geo-fencing, letting users set up safe boundaries. If there are abnormal health readings, environmental dangers, or boundary breaches, automated alerts are sent to registered guardians using GSM communication and cloud services. The camera module boosts monitoring by offering visual confirmation in emergencies.

The device runs on a 12V battery, which is converted and regulated to 5V DC to maintain stable and safe operation of all components. The system is built to use low power, ensure reliable data transmission, and maintain continuous monitoring. By bringing together multiple safety features in a compact IoT framework, this invention offers an effective and affordable solution for monitoring child health, detecting environmental safety issues, and managing location-based security.

Keywords: ESP32, GSM-GPS, IoT, Embedded C, Cloud.

I. INTRODUCTION

In recent years, the rapid growth of urbanization, increasing school mobility, and rising safety concerns have created an urgent need for intelligent child monitoring systems. Incidents such as accidental wandering, exposure to hazardous environments, health emergencies, and lack of real-time parental awareness highlight the limitations of traditional supervision methods. To address these challenges, this project proposes a **GEO-Fence Integrated IoT Framework for Health and Safety Monitoring in Children**, an advanced wearable-based monitoring system that combines location tracking, physiological monitoring, environmental sensing, and instant alert mechanisms into a single unified platform.

The proposed system is built around the **ESP32 microcontroller**, which serves as the central processing and communication unit due to its high performance, low power consumption, and built-in Wi-Fi and Bluetooth capabilities. The device integrates multiple sensors, including a **pulse sensor** for heart rate monitoring, a **temperature sensor** for body temperature analysis, a **smoke sensor** and **gas sensor** for environmental hazard detection, and an **alcohol sensor** for detecting harmful exposure conditions. while a **camera module** enhances real-time visual monitoring when required. All sensor data is processed by the ESP32 and displayed locally on an **LCD display**, while critical alerts are transmitted through a **GSM-GPS module** for real-time location tracking and emergency communication.

A major feature of the system is its **Geo-Fencing mechanism**, where a predefined safe boundary is established using GPS coordinates. If the child moves beyond the authorized zone, the system automatically triggers alerts via GSM and cloud-based notification services. The real-time location data is uploaded to a cloud platform, enabling guardians to monitor the child's position, health parameters, and environmental conditions through a mobile application. In emergency situations, the system activates a **buzzer alert**, sends SMS notifications, and shares live coordinates to predefined guardian contacts, ensuring immediate response.

The hardware architecture is powered by a **12V rechargeable battery supply**, which is regulated and rectified to a stable **5V DC output** for safe operation of the ESP32 and associated modules. A voltage regulator circuit ensures efficient power distribution and device protection. The integration of hardware and software is achieved using

Embedded C programming for sensor data acquisition, signal processing, decision-making algorithms, and secure data transmission. Encryption techniques are implemented to ensure data privacy and prevent unauthorized access.

Overall, the proposed system provides a comprehensive, low-cost, portable, and intelligent child safety solution. By combining health monitoring, environmental detection, real-time location tracking, cloud alert notifications, and emergency response mechanisms into a single IoT framework, this project aims to enhance parental confidence, reduce safety risks, and contribute toward the development of smart, secure child monitoring ecosystems.

II. LITERATURE SURVEY

1. IoT-Based Child Tracking System: This paper presents an Internet of Things (IoT) based child tracking and monitoring system designed to enhance child safety through real-time location and health monitoring. The proposed system integrates a GPS module for location tracking and GSM communication for transmitting emergency alerts to guardians. Additionally, the system incorporates physiological monitoring using a heart rate sensor to detect abnormal health conditions. The collected data is transmitted to a cloud platform for remote supervision and analysis. In emergency situations, automatic alerts are generated and sent to registered contacts, ensuring immediate parental response. The study demonstrates that IoT-enabled wearable systems can significantly improve child safety by combining tracking, communication, and health monitoring in a compact and portable device.

2. Child Safety Device with GPS Tracking and Alert Messaging: This research work proposes a wearable child safety device is designed to address increasing concerns regarding child security in public and school environments. It utilises embedded controllers along with GPS and GSM modules to continuously monitor the child's location and transmit updates to parents through SMS notifications. The implementation emphasises low power consumption, portability, and reliability. The results indicate that integrating real-time tracking with alert messaging provides an effective technological solution for enhancing child protection and parental assurance.

3. A Smart Wearable Device for Child Monitoring and Tracking System Using IoT Technology: This paper introduces a smart wearable IoT-based device for monitoring and tracking children in real time. The system employs GPS technology to define geo-fencing boundaries and generate alerts whenever the child moves beyond predefined safe zones. The wearable device communicates with guardians through wireless communication modules and cloud-based services. The architecture focuses on continuous location tracking, user-friendly mobile interfaces, and secure data transmission. Experimental evaluation shows that the system effectively detects boundary violations and ensures timely alert notifications. The study highlights the potential of IoT-based wearable solutions in improving child safety and enabling real-time parental supervision.

III. EXISTING SYSTEM

Existing child monitoring and safety systems primarily focus on **single-parameter tracking**, most commonly GPS-based location monitoring. These systems generally consist of a GPS module and a GSM communication unit that transmit the child's real-time location to parents via SMS or mobile applications. While such systems provide basic tracking functionality, they lack integration with health monitoring and environmental hazard detection.

Most available wearable child tracking devices only provide:

- Real-time GPS location updates
- Basic emergency button for manual alert
- SMS notification using GSM module

However, several limitations are observed in these systems:

1. Lack of Health Monitoring: Existing tracking devices do not continuously monitor physiological parameters such as heart rate or body temperature. Therefore, they cannot detect sudden health emergencies like abnormal pulse rate, fever conditions, or stress-related abnormalities.
2. No Environmental Hazard Detection: Most traditional systems do not include smoke, gas, or alcohol sensors. This means they cannot detect dangerous environmental conditions such as fire hazards, toxic gas exposure, or harmful surroundings.
3. Limited Geo-Fencing Intelligence: Although some systems provide geo-fencing, they often rely only on boundary alerts without integrating health or contextual analysis. Alerts are generated only when the child crosses a predefined area, ignoring other risk factors.
4. No Integrated Cloud-Based Analytics: Existing systems typically send location data via SMS without cloud storage or long-term monitoring capabilities. This prevents historical data analysis, trend monitoring, or health pattern evaluation.

5. Absence of Real-Time Visual Monitoring: Most current devices do not integrate camera modules for capturing images during emergency conditions, reducing situational awareness for guardians.
6. Power Management Limitations: Many traditional systems use basic battery supply without regulated power conversion, leading to unstable performance and reduced operational efficiency.
1. Because of these limitations, current child safety systems provide **partial protection**, focusing only on tracking rather than comprehensive health and safety monitoring.

IV. PROPOSED SYSTEM

The proposed system, titled **"GEO-Fence Integrated IoT Framework for Health and Safety Monitoring in Children"**, introduces a **multi-layered, intelligent monitoring solution** that integrates location tracking, health monitoring, environmental detection, and real-time alert mechanisms into a single wearable framework.

The system architecture is built around the **ESP32 microcontroller**, which manages sensor data acquisition, processing, and communication.

1. Integrated Health Monitoring

The proposed system continuously monitors:

- **Pulse Sensor** → Real-time heart rate monitoring
- **Temperature Sensor** → Body temperature tracking

If abnormal health parameters are detected, the system immediately triggers alerts through GSM and cloud notifications.

2. Environmental Hazard Detection

The device integrates:

1. **Smoke Sensor** → Detects fire-related hazards
2. **Gas Sensor** → Identifies toxic gas exposure
3. **Alcohol Sensor** → Detects unsafe environmental exposure

When hazardous levels are detected, the system activates:

- **Buzzer alert**
- **SMS notification to guardians**
- **Cloud-based emergency alert**

3. Advanced Geo-Fencing Mechanism

Using the **GSM-GPS module**, predefined safe zones are configured. If the child moves beyond the boundary:

- Instant alert is sent to guardian
- Real-time coordinates are transmitted
- Location is updated on mobile application
- Cloud data logging is performed

4. Camera-Based Situational Awareness

A **camera module** captures real-time images when triggered by emergency conditions. This improves decision-making and provides visual verification of the child's environment.

5. LCD Display Interface

An integrated **LCD display** shows:

- Heart rate
- Temperature
- Location status
- Alert messages

This ensures local visibility of system status.

6. Cloud-Based Monitoring and Data Storage

All data is uploaded to a cloud platform for:

- Continuous monitoring
- Historical health record analysis
- Location tracking history
- Alert documentation

This enhances reliability and long-term supervision.

7. Power Management System

The system operates using:

- **12V battery supply**
  Voltage regulation and rectification to a stable **5V**
- **DC output**

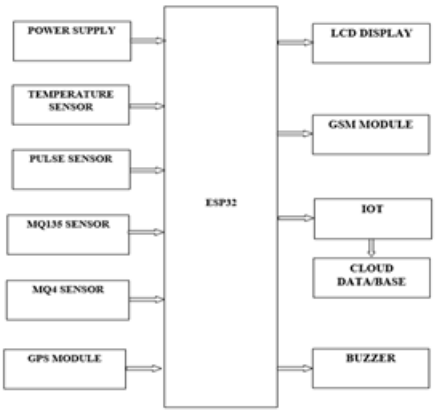
This ensures safe and efficient power distribution for the ESP32 and sensors.

8. Secure Embedded Software Implementation

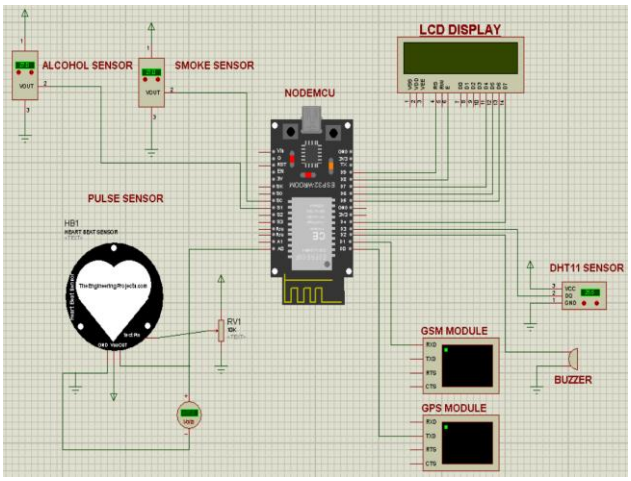
The entire system is programmed using Embedded C, implementing:

- Sensor data filtering algorithms
- Threshold-based decision logic
- Encrypted communication protocols
- Automated alert generation system

BLOCK DIAGRAM



CIRCUIT DIAGRAM



WORKING PRINCIPLE

1. The GEO-Fence Integrated IoT Framework for Health and Safety Monitoring in Children operates on the principle of continuous sensor-based data acquisition, real-time processing, and automated alert generation using an embedded microcontroller system. The ESP32 microcontroller serves as the central processing unit that collects data from various sensors, analyses the information, and triggers appropriate responses based on predefined safety conditions.
2. Initially, when the device is powered using a 12V battery supply, the voltage is rectified and regulated to a stable 5V DC output to ensure safe and efficient operation of the ESP32 and connected modules. Once powered on, the ESP32 initialises all sensors, including the pulse sensor, temperature sensor, smoke sensor, gas sensor, alcohol sensor, GSM-GPS module, LCD display, buzzer, and camera module. The system then enters continuous monitoring mode.
3. The pulse sensor measures the child's heart rate in beats per minute (BPM), while the temperature sensor records body temperature at regular intervals. These physiological parameters are transmitted to the ESP32, where they are compared with predefined threshold values stored in the program. If the heart rate or temperature exceeds normal limits, the system identifies it as a health abnormality and activates the emergency alert mechanism.
4. Simultaneously, the smoke sensor, gas sensor, and alcohol sensor monitor the surrounding environment for harmful conditions. If the detected levels exceed safe limits, the microcontroller activates the buzzer for local warning and sends an alert message to the registered guardian via the GSM module. This ensures immediate response during hazardous environmental exposure.
5. The GSM-GPS module continuously retrieves the child's geographical coordinates. A predefined geo-fence boundary is programmed into the system. The ESP32 compares real-time GPS data with the stored boundary limits. If the child moves beyond the authorized area, the system detects a geo-fence breach and automatically transmits an alert notification along with location details to the guardian's mobile device and cloud platform.
6. During emergency conditions such as abnormal health readings or geo-fence violations, the camera module can be triggered to capture real-time images for enhanced situational awareness. The LCD display shows real-time sensor values and system status locally. All collected data may also be uploaded to a cloud server for remote monitoring and historical record analysis.
7. Thus, the working principle of the system is based on continuous sensing, intelligent decision-making using embedded programming, and automated multi-level alert communication to ensure comprehensive health and safety monitoring of children.

V. RESULT

The Geo-Fence Integrated IoT Framework for Health and Safety Assurance in Children was successfully implemented and tested. The system accurately monitored heart rate and body temperature using pulse and DS18B20 sensors. MQ-2 and MQ-3 sensors effectively detected smoke and alcohol levels, triggering alerts when thresholds were crossed. GPS module provided real-time location with successful geo-fence boundary detection within 100-meter radius. All data was reliably uploaded to Thing Speak cloud and emergency SMS alerts were sent via GSM module. The LCD displayed live parameters and the overall system performed reliably with stable power supply.

VI. CONCLUSIONS

The Geo-Fence Integrated IoT Framework successfully combines health monitoring, environmental hazard detection, GPS tracking, and geo-fencing into a single compact system. The ESP32-based prototype provides real-time alerts through buzzer, GSM, and cloud services. It overcomes the limitations of existing child tracking devices by offering multi-parameter monitoring. The system is cost-effective, portable, and user-friendly for guardians. Testing results confirmed reliable performance in simulated real-world conditions. This project contributes significantly to enhancing child safety using IoT technology.

VII. FUTURE SCOPE

The proposed system can be further enhanced in the future by miniaturizing it into a lightweight wearable device. Additional sensors like accelerometer for fall detection and SpO2 for oxygen monitoring can be integrated. A dedicated mobile application with push notifications and interactive maps can be developed. Live video streaming and AI-based risk prediction can be added for better performance. Power management can be improved using solar charging and advanced low-power modes. The framework can also be extended for elderly care and pet tracking applications.

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